Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 87 (2015) 35479-35485

ISSN: 2229-712X

Orange production assessment and analysis of the relationship between energy input and yield in the sari region of Iran

Peyman Qasemi-Kordkheili*, Mohammad Amin Asoodar and Navab Kazemi

Department of Agricultural Machinery Engineering and mechanization, Khuzestan Ramin Agricultural and Natural Resources University, Mollasani, Ahvaz, Iran.

ARTICLE INFO

Article history:

Received: 11 March 2013;

Received in revised form:

21 September 2015;

Accepted: 26 September 2015;

Keywords

Cobb-Douglas,

Energy indices,

Orange production,

Sari.

ABSTRACT

Studies on orange production in Mazandaran province are necessary due to its potential for production and large cultivation area. In this study energy input-output, economic analysis and econometric modeling of energy input for orange production in Sari region of Iran were carried out. From a total of 86 farmers considered for the analysis, the total input and output energy were 54.2 and 59.2 GJ ha^{-1}, respectively. Diesel fuel, fertilizer and water had the highest energy values per hectare, respectively. Results showed that the overall energy ratio (Energy use efficiency) was calculated as 1.09. The relationships between various energy sources and yield were found using Cobb-Douglas production function. Econometric models showed that among all energy sources chemical fertilizer, farmyard manure and water for irrigation had the most significant impact on orange yield. Additionally, economic analysis was carried out with results showing that the benefit to cost ratio and net return for orange production were 10.6 and 16420.4 \$ h^{-1}, respectively.

Introduction

The orange (specifically, the sweet orange) is the fruit of citrus trees belonging to the *Rutaceae* family and *Aurantioideae* subfamily. Annual production and cultivation area placed Iran in the top 10 orange-producing countries of the world (Singh et al., 2002). Based on FAO statistics, about 7.75 million tons of citrus are consumed worldwide each year. In 2008, 5500 ha of land were allocated to citrus farming and about 80,000 tons were produced in Iran (FAO, 2010). Citrus is the most important horticultural crop in Mazandaran province with about 40% of annual citrus production in Iran, produced in this region (Anonymous, 2005). Recently, the agriculture sector, like other sectors, has become increasingly dependent on energy resources such as electricity, fuels, natural gas and coke. This increase in energy use and its associated increase in capital intensive technology can be partially attributed to low-energy prices in relation to the resource for which it is being substituted (Karkacier et al., 2006). Modern crop production is characterized by a high input of fossil-fuel energy, which is consumed as direct energy and indirect energy (Tabatabaie et al., 2013).

Energy analysis can be used as a first step towards identifying crop production processes that benefit most from increased efficiency (Mohammadi et al., 2008). Analyzing the input–output energy on agricultural crops has been done to evaluate and compare the efficiency of production systems. Several investigators focused on energy input–output relation analysis. Triolo et al. (1987) surveyed energy use patterns in agriculture for crops such as wheat, maize, sugar beet and grapes in Italy. Other studies carried out on orchard crops include: Strapatsa et al. (2006) investigated energy flow for integrated apple production in Greece, Sartori et al. (2005) studied apricot and plum energy usage patterns in Italy, Tabatabaie et al. (2013) and Mohammadi et al. (2010) investigated energy input-yield relationships and cost analysis for pear and kiwifruit production in Iran, respectively, and Erdal et al. (2009) the functional relationship between energy input sources and fruit yield of stake tomato in Turkey. After reviewing the literature it was determined that there had been no previous study to cover economic analysis and modeling of energy input sources for orange production in Iran. With regards to the potential of Mazandaran province to increase its orange production, in this study the energy use patterns and economic indices were investigated and the relationships between energy input sources and yield on orange production in the Sari region of Iran are discussed.

Materials and methods

This study was conducted in the Sari region of the province of Mazandaran, located in the north of Iran between the northern slopes of the Alborz Mountains and southern coast of the Caspian Sea, within 35° 58 and 36° 50 north latitude and 52° 56 and 53° 59 east longitude. The mean yearly relative humidity is 85.83%, and the average temperature is about 17°C. Also, the Sari is a rainy region, and has enough rainfall for cropping throughout all seasons of the year. Data were collected using the personal interview method in a specially designed schedule during the 2011/2012 production year. The size of each sample was determined using Eq. (1) (Kizilaslan, 2009):

$$n = \frac{N(S \times T)^2}{(N-1)d^2 + (S \times T)^2} \quad (1)$$

Where *n* is the required sample size; *N* is the number of holdings in the target population; *S* is the standard deviation; *T* is the t-value at a 95% confidence limit (1.96); and *d* is the acceptable- error (permissible error 5%). Thus the calculated sample size in this study was determined to be 86 orange farms.

Tele:

E-mail addresses: p.qasemi88@gmail.com

Consequently, based on this number, 86 orange farmers in the Sari County were randomly selected. In this study gathered data included the quantity of eight energy input sources used per hectare of orange production: human power, machinery, diesel fuel, chemicals, fertilizer, farmyard manure, water for irrigation and electricity.

To calculating the embodied energy in agricultural machinery it was assumed that the energy consumed for the production of the tractors and agricultural machinery is depreciated during their economic life time (Mousavi-Avval et al., 2011b). Therefore, the machinery energy input was calculated using the Equation (2) (Gezer et al., 2003).

$$ME = \frac{G \times Mp \times t}{T} \quad (2)$$

Where *ME* is the machinery energy per unit area ($MJha^{-1}$); *G* is the machine mass (kg), *Mp* is the production energy of machine ($MJkg^{-1}$); *t* is the time that machine used per unit area (hha^{-1}) and *T* is the economic life time of machine (h). Only orange production yield was used to calculate output energy. The data were calculated for 1 hectare, converted into energy units and expressed in MJ ha^{-1}. The energy equivalents of all 8 input sources were used to calculate the input amounts and are given in Table- 1.

Table 1. Energy equivalent coefficients of inputs and output

Item	Units	Energy equivalent (MJ $unit^{-1}$)	References
Input			
1.Diesel Fuel	l	47.8	(Rabari et al., 2013)
2.Electricity	kWh^{-1}	11.93	(Mohammadi and Omid 2010)
3.Human Power	h	1.96	(Qasemi kordkheili et al., 2013)
4.Water for irrigation	m^3	1.02	(Qasemi kordkheili et al., 2013)
5.Machinery	kg	62.7	(Sing and Mital 1992)
6.Fertilizer	kg		
Nitrogen		66.44	(Mohammadi and Omid. 2010)
Phosphate (P_2O_5)		12.44	(Mohammadi and Omid. 2010)
Potassium (K_2O)		11.15	(Mohammadi and Omid. 2010)
Sulfur (S)		1.2	(Mohammadi et al. 2010)
7.Farmyard manure		0.3	(Qasemi kordkheili et al., 2013)
8.Chemicals	kg		
Herbicides		238	(Rafiee et al., 2010)
Pesticides		199	(Namdari et al., 2011)
Fungicide		92	(Ozkan et al., 2004)
Output			
1.Oranges	kg	1.9	(Ozkan et al., 2004)

Based on the energy values for the inputs and output presented in Table- 1, the energy ratio (energy use efficiency), energy productivity, specific energy and net energy were defined by the following equations (Mohammadi and Omid, 2010; Qasemi kordkhili et al., 2013):

Energy Efficiency = energy output (MJ ha^{-1}) / energy input (MJ ha^{-1}) (3)

Energy Productivity = orange output (kg ha^{-1}) / energy input (MJ ha^{-1}) (4)

Specific Energy= energy input (MJ ha^{-1}) / orange output (kg ha^{-1}) (5)

Net energy = Energy output (MJ ha^{-1}) – Energy input (MJ ha^{-1}) (6)

Energy efficiency is one of the main energy indices used to determine overall productivity in the agricultural sector. In the other words, this ratio, which is calculated as the ratio between input fossil fuel energy and output food energy, is one commonly used to express the effectiveness of crop production in developed countries (Mousavi-Avval et al., 2011a). A farmer’s main objective is to develop production systems to increase energy efficiency. Additionally, to analyze the economic indices for each orchard, many economic indicators need to be calculated (Tabatabaie et al., 2013 and Samavatean et al., 2011).

Gross value of production = Sale price ($ kg^{-1}) × Yield (kg ha^{-1}) (7)

Productivity = orange yield (kg ha^{-1}) / Total production costs ($ ha^{-1}) (8)

Benefit to cost ratio = Total production value ($ ha^{-1}) / Total production costs ($ ha^{-1}) (9)

Gross return = Total production value ($ ha^{-1}) – Variable cost of production ($ ha^{-1}) (10)

Net return = Total production value ($ ha^{-1}) – Total production costs ($ ha^{-1}) (11)

Energy demand in the agriculture sector can be divided into direct and indirect energies or alternatively as renewable and non-renewable energies (Rahbari et al., 2013). Indirect energy is the energy spent outside the farm for the manufacture of many input sources such as fertilizers and machinery (Tabatabaie et al., 2013) and includes the energy embodied in fertilizers, farmyard manure, chemicals and machinery while direct energy consists of human labor, electricity, diesel fuel, and water for irrigation. Non-renewable energy consists of diesel, chemicals, electricity, fertilizers and machinery energies while renewable energy includes human labor, farmyard manure and water energies (Mousavi-Avval et al., 2011b).

The production function specifies the output of an orchard for all combinations of input energy sources. The Cobb-Douglas production function yielded the best estimates in terms of statistical significance and expected signs of parameters (Mobtaker et al., 2010) and is expressed as:

$$Y = f(x) \exp(u) \quad (12)$$

This function has been used by several authors to examine energy input and yield relation (Mobtaker et al., 2010; Samavatean et al., 2011 and Mousavi-Avval et al., 2011a).

This function can be written in linear form as:

$$\ln Yi = \alpha_0 + \sum_{j=1}^{n} \alpha_j \ln(X_{ij}) + e_i \qquad i = 1,2,3,\ldots \quad (13)$$

where Y_i denotes the yield level of the i^{th} farmer, X_{ij} is the vector inputs used in the production process, is the constant term, α_j represents coefficients of inputs which are estimated from the model and e_i is the error term. In this study Eq. (12) can be expressed in this form (Samavatean et al., 2011):

$$\text{Mode l I: } \ln Y_i = \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + \alpha_8 \ln X_8 + e_i \quad (14)$$

where Y_i denotes the yield level of the i'th farmer, X_1 is water energy, X_2 is human labor energy, X_3 is machinery energy, X_4 is electricity energy, X_5 is chemical fertilizer energy, X_6 is diesel fuel energy, X_7 is chemical biocide energy and X_8 is farm yard manure energy. The effects of direct, indirect, renewable and non-renewable energies on production were modeled using the following equations (Rafiee et al., 2010):

$$\text{Model II: } \ln Y_i = \beta_1 \ln(DE) + \beta_2 \ln(IDE) + e_i \quad (15)$$

$$\text{Model III: } \ln Y_i = \gamma_1 \ln(RE) + \gamma_2 \ln(NRE) + e_i \quad (16)$$

where Y_i denotes the yield level of the i'th farmer, β_1 and γ_1 are coefficient of exogenous variables. Also, DE, IDE, RE, and NRE are direct, indirect, renewable and non-renewable energies, respectively.

Table 2. Energy input sources, output and their energy equivalents for orange production

Input	Quantity per unit area (Unit ha^{-1})	Total energy equivalent (MJ ha^{-1})
1.Diesel Fuel (L)	281.9	13475.3
2.Electricity (kWh)	363.9	4352.5
3.Human Power (h)	1342.3	2631.3
4.Water (m^3)	11835.5	12072.3
5.Machinery (kg)	4664.1	974.81
6.Fertilizers (kg)		12418.4
Nitrogen	91.5	6079.2
Phosphate (P_2O_5)	326.8	4065.3
Potassium (K_2O)	200.4	2234.4
Sulphur (S)	33.0	39.6
7.Farmyard manure	15891.1	4768.8
8.Chemicals (kg)		3590.0
Herbicides	8.3	1990
Pesticides	3.99	795
Fungicide	8.75	805
Total energy input		54284.8
Total energy output	31170.2	59223.4

Results and discussion

In this study, 86 orchards in 3 levels of area were carried out. Orchards were divided into 3 groups by size: under 2 hectares, between 2 and 6 hectares and larger than 6 hectares. Orchard operations included autumn pruning, fertilization, spraying, irrigation and harvesting.

Analysis of input-output energy use in orange production

The physical input sources and their energy equivalents used in the production of orange are presented in Table- 2.

As can be seen in Table- 2, the total amount of energy input and output are 54284.8 and 59223.4 MJ ha^{-1}, respectively. In the other words, the average orange yield was 31270.2 kg ha^{-1}. Farmers used, in total, 651.7 kg of fertilizers, 15891.1 tons of farmyard manure and 21.04 kg of chemical agents per hectare. They also used 1342.3 hr of human power, 281.9 L of diesel fuel, 11835.5 m^3 of water for irrigation and 363.9 kWh of electrical energy per hectare for the production of oranges in Mazandaran province. The large amount of water usage in this area is the result of farmers irrigating on average 8-10 times during each production year. Many famers use diesel motor pumps to irrigate orchards but the remaining farmers use electrical motor pumps with the result that electricity is consumed only for irrigation purposes. Drop and flood irrigating were the two irrigating system used. 54 orchards were irrigated with a flooding system that caused water wastage, while remaining orchards were equipped with a drop irrigation system. Drop irrigating system has high fixed costs.

In calculation of machinery energy 50 hr usage of machines in average per hectare and economic life were considered, so the total machinery energy input for orange production was 947 MJha^{-1}. Among all farmers, tractors were widely used in all operations. In many operations such as irrigation, tractors are only used to transport water pump motors and pipes so it was a cause of energy wastage and inefficiency. Generally, machinery power was primarily used in spraying operations. The low amount of machinery usage shows that in all operations human power was involved, mainly during the harvesting stage. Additionally, the large amount of diesel fuel used can be explained as the use of ancient tractors and inefficient motor pumps. The distribution of energy source inputs used in orange production illustrated in Figure 1.

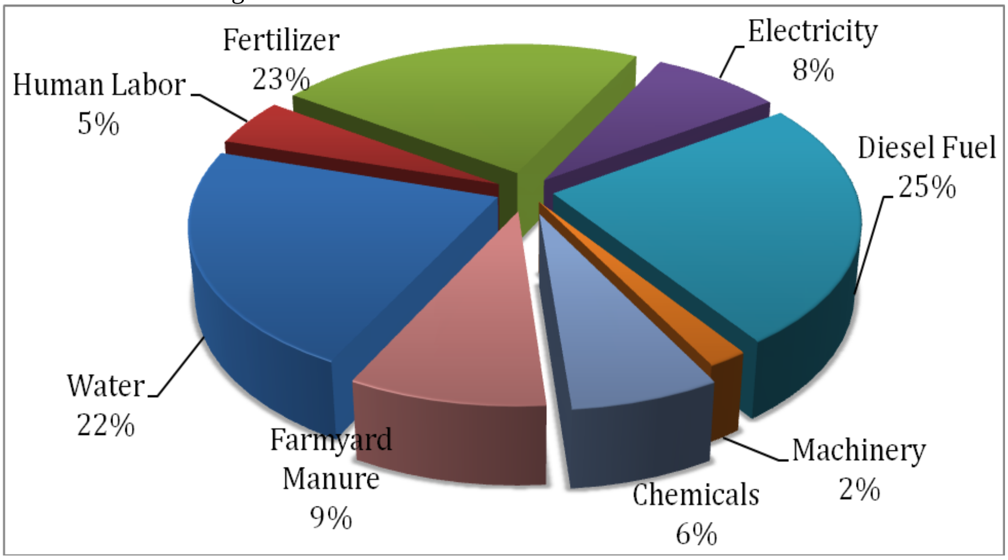

Figure 1. The distribution of energy source inputs used in the production of oranges

In similar research in the Mazandaran province of Iran, Namdari et al. (2011) found that the total energy used in various farm operations during orange production was 62375.1 MJ ha^{-1}. The highest energy input was provided by diesel fuel followed by chemical fertilizer. Additionally, Ozkan et al. (2004) found similar results for orange, mandarin and lemon productions in Turkey. Rafiee et al. (2010) in their study on apple production in Iran, indicate that the total energy consumption was 42819.2 MJ ha^{-1} and the energy input of diesel fuel was the biggest share of the total energy input followed by farmyard manure and electricity. Also, Mohammadshirazi et al. (2012) found that the total energy requirement for the production of tangerine crops in the Mazandaran province of Iran is about 62260 MJ ha^{-1} and chemical fertilizers had the highest energy consumption. Qasemi kordkheili et al. (2013) reported that for soybean production in the Mazandaran province of Iran the total energy input was about 38.7 Gjha^{-1}, and that the highest share was the consumption of electrical energy, followed by fertilizers..

Energy ratio, energy productivity, specific energy and net energy gain and the distributions of energy sources into direct, indirect, renewable and non-renewable energy groups are given in Table- 3.

Table 3. Energy input-output in orange production

Item	Unit	Value
Energy efficiency	-	1.09
Energy productivity	kg MJ^{-1}	0.57
Specific energy	MJ kg^{-1}	1.74
Net energy	MJ ha^{-1}	4938.5
Direct energy [a]	MJ ha^{-1}	32531.5
Indirect energy [b]	MJ ha^{-1}	21735.2
Renewable energy [c]	MJ ha^{-1}	19472.4
Non- renewable energy [d]	MJ ha^{-1}	34812.3
Total energy input	MJ ha^{-1}	54284.8
Total energy output	MJ ha^{-1}	59223.4

[a] Includes human labor, diesel fuel, water for irrigation, electricity.
[b] Includes chemical fertilizers, farmyard manure, chemicals agents, machinery.
[c] Includes human labor, farmyard manure, water for irrigation.
[d] Includes diesel fuel, electricity, chemicals , chemical fertilizers, machinery.

The overall energy ratio (Energy use efficiency) was calculated as 1.09. Energy productivity was calculated as 0.57 kg MJ^{-1} meaning that for every 1 MJ of energy consumed farmers can produce 0.57 kg of orange fruit. Ozkan at al. (2004) in Turkey calculated the energy ratio as 1.25 for orange production. In similar research Namdari et al. (2010) and Qasemi Kordkheili et al. (2013) reported that the energy ratio and the energy productivity of orchards for orange and nectarine production was 0.99, 0.52 kg MJ^{-1} and 1.36, 0.77 kg MJ^{-1} in the Mazandaran province of Iran, respectively. Also, Specific energy and net energy were measured as 1.74 MJ kg^{-1} and 4938.5 MJ ha^{-1}, respectively. The distribution of energy consumption from direct, indirect, renewable and non-renewable energy resources was also investigated. The results revealed that total energy input was 32531.5 and 21735.2 MJ ha^{-1} in direct and indirect, and 19472.4 and 34812.3 MJ ha^{-1} in renewable and non-renewable energy forms, respectively. It is clear that 64.1

% of total consumed energy was from non-renewable energy sources. This amount is lower than other measured amounts of non-renewable energy for other crops such as 86% of total energy for pear production in Iran (Tabatabaie et al., 2013), and 73.36% of total energy for kiwifruit production in Iran (Mohammadi et al., 2011).

Energy Consumption and Output Yield analysis Based on Orchard Area

The suitable climatic conditions and relative availability of necessary input energy sources, especially irrigation water and soil for production of different garden products, has made Mazandaran province one of the most important producers of agricultural commodities in Iran. Thus, adoption of informed agricultural policy in this region is necessary. One of these aspects is integrating and centralizing orchards. The amount of energy input and output divided by orchard size are given in Table- 4. The amount of inputs and output are express as MJ ha^{-1}.

Table 4. Amount of energy input and orange yield by orchard size

Orchard area (ha)	Water for irrigation	Human Labor	Fertilizer	Electricity	Diesel Fuel	Machinery	Chemicals	Farmyard Manure	Orange output
0 to 2	12465	2980	19400	4800	14307	1160	3620	4860	58875
2 to 6	11938	2700	12350	4540	14045	1027	3437	4504	59980
< 6	12344	2556	12260	4025	12670	930	3500	4650	65305
Total	12070	2630	12410	4350	13470	970	3590	4760	59220

As can be seen in Table- 4, by increasing orchard area and with better orchard energy management in larger orchards compared to small orchards, energy consumption of many input energies such as, human labor, machinery, electricity and diesel fuel considerably decrease while other inputs stay about the same. Subsequently, by increasing an orchard's area total orange yields increase. The obtained result shows that integrating and centralization orchards can decrease energy consumption.

Econometric modeling of energy inputs

For the estimation of energy input sources and their individual relationships to orange yield the Cobb-Douglas production function was applied. Orange yield (endogenous variable) was assumed to be a function of eight inputs used in production including; water for irrigation, human labor, machinery, electricity, chemical fertilizer, diesel fuel, chemicals and farmyard manure (exogenous variables). The R^2 value (coefficient of determination) of this equation was determined to be 0.81 meaning that 0.81 of the variability in the energy input sources can be described by this model. The results of econometric estimation are shown in Table- 5.

Table 5. Econometric estimation of the result of different energy input sources

	Coefficient	*t*-ratio
Endogenous variable: yield		
Model I: $\ln Y_1 = \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + \alpha_8 \ln X_8 + e_1$		
Exogenous variables:		
Water for irrigation	0.25	2.67**
Human labor	0.07	0.86
Machinery	-0.03	-0.75
Electricity	0.00	-1.21
Chemical fertilizer	0.42	4.99**
Diesel fuel	0.15	1.54
Chemicals	-0.02	-0.29
Farm yard manure	0.15	2.48*
R^2	0.81	
Returns to scale	0.985	

* and ** indicate significance at 5% and 1% levels respectively.

Table-5 shows that chemical fertilizer and water contributed significantly to productivity at 1% probability level. Additionally, chemical fertilizer had the highest impact (0.42) among all inputs. It indicates that a 1% increase in the water or chemical fertilizer led to 0.42% increase in yield energy in these conditions of production. Rafiee et al. (2010) in an estimated econometric model on apple production, reported that human labor, chemical fertilizers, farm yard manure, water and electricity energies had significant impacts on improving yield (Rafiee et al., 2010). Mohammadi et al. (2010) in other study on kiwifruit reported that human labor, machinery, chemical fertilizers and water energies increase yield with significant additional impact. Table- 6 presents the results of econometric models of direct, indirect, renewable and non-renewable forms of energy.

Table 6. Econometric estimation results of energy forms

Exogenous variables	Coefficient	*t*-ratio
Model II: $\ln Y_1 = \beta_1 \ln (DE) + \beta_2 \ln (IDE) + e_1$		
1. Direct energy	0.16	1.41
2. Indirect energy	0.84	9.41**
R^2	0.75	
RTS	0.997	
Model III: $\ln Y_1 = \gamma_1 \ln (RE) + \gamma_2 \ln (NRE) + e_1$		
1. Renewable energy	0.75	9.36**
2. Non-renewable energy	0.28	2.82**
R^2	0.75	
RTS	1.025	

* and ** indicate significance at 5% and 1% levels respectively.

Model II showed that, the impact of indirect energy in orange production was significant at a 1% probability level with a 0.84 regression coefficient. Model III explains the significance impact for both renewable and non-renewable energy forms with 0.75 and 0.28 regression coefficients, respectively. In a study on tangerine production, econometric model on energy forms represented that all forms of energy (D, ID, RE and NRE) had significant impacts on yield (Mohammadshirazi et al., 2012). In apple production Rafiee et al. (2010) reported that direct, indirect, renewable and non-renewable energy forms had significant impact on yield with 1.48, 0.46, 0.70 and 1.31 regression coefficients respectively.

Economic Analysis of Orange Production

Based on costs of each energy inputs source and the sale price of yield in this production year, productivity, benefit to cost ratio, net return and gross return were calculated. The total expenditure in orange production is categorized into fixed costs and variable costs. Variable costs relate to energy input costs in this studied growing season. The results are given in Table- 7.

Table 7. Economic indices for orange production in 2011/2012 growing season

Cost and return components	Unit	Value
Yield	kg ha^{-1}	31270.2
Sale price	\$ kg^{-1}	0.6
Gross value of production	\$ ha^{-1}	18702
Variable cost of production	\$ ha^{-1}	1530
Fixed cost of production	\$ ha^{-1}	230
Total cost of production	\$ ha^{-1}	1760
Total cost of production	\$ kg^{-1}	0.056
Gross return	\$ ha^{-1}	16650.4
Net return	\$ ha^{-1}	16420.4
Benefit to cost ratio	-	10.6
Productivity	kg \$$^{-1}$	17.7

In this study 87% of total costs were related to variable costs and 13% related to fixed costs. Several studies also reported that the proportion of variable costs was higher than fixed costs in cropping systems (Cetin and Vardar, 2008; Mohammadi and Omid, 2010 and Samavatean et al., 2011). The high value of variable costs can be explained by the increasing costs of chemical fertilizer, diesel fuel and chemical agents in Iran, in recent years. The benefit to cost ratio was determined as 10.6, the productivity ratio was found to be 17.7 kg \$$^{-1}$, and net return and gross return were calculated as 16420.4 and 16650.4, respectively. In other studies the benefit to cost ratio was determined as 3.11 for pear production (Tabatabaie et al., 2013), 1.36 for garlic production (Samavatean et al., 2011) and 2.08 for grape production (Rajabi Hamedani et al., 2011) in Iran. Economic analysis results showed that orange production in the surveyed area, despite the high amounts of consumed diesel fuel and fertilizer is tangibly beneficial.

Conclusions

In this study, the energy balance between the input and output for orange production in the Sari region of Iran was investigated and the following conclusions are drawn:

1. The total amount of energy consumed and total output energy for orange production were 56.7 GJ ha^{-1} and 59.2 GJ ha^{-1}, respectively. Among input energy sources, diesel fuel and chemical fertilizers had the highest share, respectively.
2. Energy ratio and energy productivity were calculated as 1.09 and 0.57 kg MJ^{-1}, respectively.
3. According to econometric model evaluations, chemical fertilizers and water energies had the most significant influence on orange production.
4. Due to increased energy input management in large orchards, integrating and centralization small orchards decreases energy consumption and increases orange yield in the survey area.

Acknowledgement

The cooperation of Mr Ammon Watkins in this study is gratefully acknowledged.

References

Anonymous, Food and Agricultural Organization (FAO). www.fao.org, 2010.

Cetin, B., Vardar, A., 2008, Economic analysis of energy requirements and input costs for tomato production in Turkey. Renewable Energy, 33:428-33.

Gezer I, Acaroglu M, Haciseferogullari H. Use of energy and labor in apricot agriculture in Turkey. Biomass Bioenergy 2003;24:215–9.

Karkacier, O., Goktolgab, ZG., Cicekb, A., 2006. A regression analysis of the effect of energy use in agriculture. Energy Policy, 34:3796-800.

Kizilaslan, H., 2009. Input–output energy analysis of cherries production in Tokat Province of Turkey. Appl. Energy, 86: 1354-58.

Mandal, KG., Saha, KP., Gosh, PL., Hati, KM., Bandyopadhyay, KK., 2002. Bioenergy and economic analyses of orange based crop production systems in central India. Biomass Bio energy, 23: 337–45.

Mobtaker, H.G., Akram, A., Keyhani, A., Mohammadi, A., 2012. Optimization of energy required for alfalfa production using data envelopment analysis approach. Energy for Sustainable Development 16, 242-248.

Mobtaker, H.G., Keyhani, A., Mohammadi, A., Rafiee, S., Akram, A., 2010. Sensitivity analysis of energy inputs for barley production in Hamedan Province of Iran. Agriculture, Ecosystems & Environment, 137, 367-372.

Mohammadi, A., Omid, M., 2010. Economical analysis and relation between energy inputs and yield of greenhouse cucumber production in Iran. Applied Energy, 87(1): 191-96.
Mohammadi, A., Rafiee, SH., Mohtasebi, SS., Mousavi Avval, SH., Rafiee, H., 2011. Energy efficiency improvement and input cost saving in kiwifruit production using Data Envelopment Analysis approach.. Renewable Energy, 36. 2573-79.
Mohammadi, A., S. Rafiee, S.S. Mohtasebi and Rafiee H, 2010. Energy inputs - yield relationship and cost analysis of kiwifruit production in Iran. Renewable Energy, 35: 1071-75.
Mohammadi, A., Tabatabaeefar, A., Shahin, S., Rafiee, S., Keyhani, A., 2008. Energy use and economical analysis of potato production in Iran a case study: Ardabil province. Energy Conversion Manage. 49: 3566-70.
Mohammadshirazi, A., Akram, A., Rafiee, Sh., Mousavi Avval, SH., Bagheri Kalhor, E., 2012. An analysis of energy use and relation between energy inputs and yield in tangerine production. Renewable and Sustainable Energy Reviews, 16 ; 4515–21.
Mousavi-Avval, S.H., Rafiee, S., Jafari, A., Mohammadi, A., 2011a. Energy flow modeling and sensitivity analysis of inputs for canola production in Iran. Journal of Cleaner Production, 19, 1464-70.
Mousavi-Avval, S.H., Rafiee, S., Jafari, A., Mohammadi, A., 2011b. The Functional Relationship between Energy Inputs and Yield Value of Soybean Production in Iran. International Journal of Green Energy, 8, 398-410.
Namdari, M., Asadi Kangarshahi, A., Akhlaghi Amiri, N., 2011. Input-output energy analysis of citrus production in Mazandaran province of Iran. African Journal of Agricultural Research, 6 (11), 2558-64.
Nassiri, SM., Singh, S., 2010. A comparative study of parametric and non-parametric energy effciency in paddy production. Journal of agricultural science and technology. 12: 379-389.
Ozkan B, Akcaoz H, Karadeniz F 2004. Energy requirement and economic analysis of citrus production in Turkey. Energy Conversion Manage, 45: 1821-30.
Qasemi Kordkheili, P., Kazemi, N., Hemmati, A., Taki, M., 2013. Energy input-output and economic analysis for soybean production in Mazandaran province of Iran. Elixir Agriculture 56, 13246-51.
Rafiee, S., Mousavi-Avval, S.H., Mohammadi, A., 2010. Modeling and sensitivity analysis of energy inputs for apple production in Iran. Energy 35 (8), 3301-6.
Rahbari, H., Mahmoudi, A., Ajabshirchi, Y., 2013. Energy consumption and application of parametric method for tomato production in Iran. International Journal of Agriculture and Crop Sciences. 5-1 89-94.
Rajabi Hamedani, S., Keyhani, A., Alimardani, R., 2011. Energy use patterns and econometric models of grape production in Hamadan province of Iran. Energy, 36, 6345-51.
Samavatean, N., Rafiee, SHM, Mobli, H., Mohammad, H., 2011. An analysis of energy use and relation between energy inputs and yield, costs and income of garlic production in Iran. Renewable Energy, 1808-13.
Sartori, L., Basso, B., Bertocco, M., Oliviero, G., 2005. Energy Use and Economic Evaluation of a Three Year Crop Rotation for Conservation and Organic Farming in NE Italy. Biosyst. Eng., 91(2), 245-56.
Singh, A., Naqvi, AA., Singh, S., 2002. Citrus Germplasm Cultivars and Rootstock. 1st Edition, Kalyani Publisher, India, pp. 5-60.
Singh S, Mittal JP, 1992. Energy in production agriculture. New Delhi, India: Mittal Publications. p. 14-8.
Strapatsa. AV., Nanos, GD., Tsatsarelis, CA., 2006.Energy flow for integrated apple production in Greece. Agric Ecosyst Environ, 116, 176-80.
Tabatabaie, SMH., Rafiee, SH., Keyhani, A., Heidari, MA., 2013. Energy use pattern and sensitivity analysis of energy inputs and input costs for pear production in Iran. Renewable Energy, 51 7-12.
The Energy and Agriculture Nexus. 2000Environment and natural resources working paper No. 4, FAO, Rome.